Lamp measurement report – d mmm yyyy

Mushroom shaped 4W WW E27
by
Line Lite International BV

Photo courtesy by www.OliNo.org

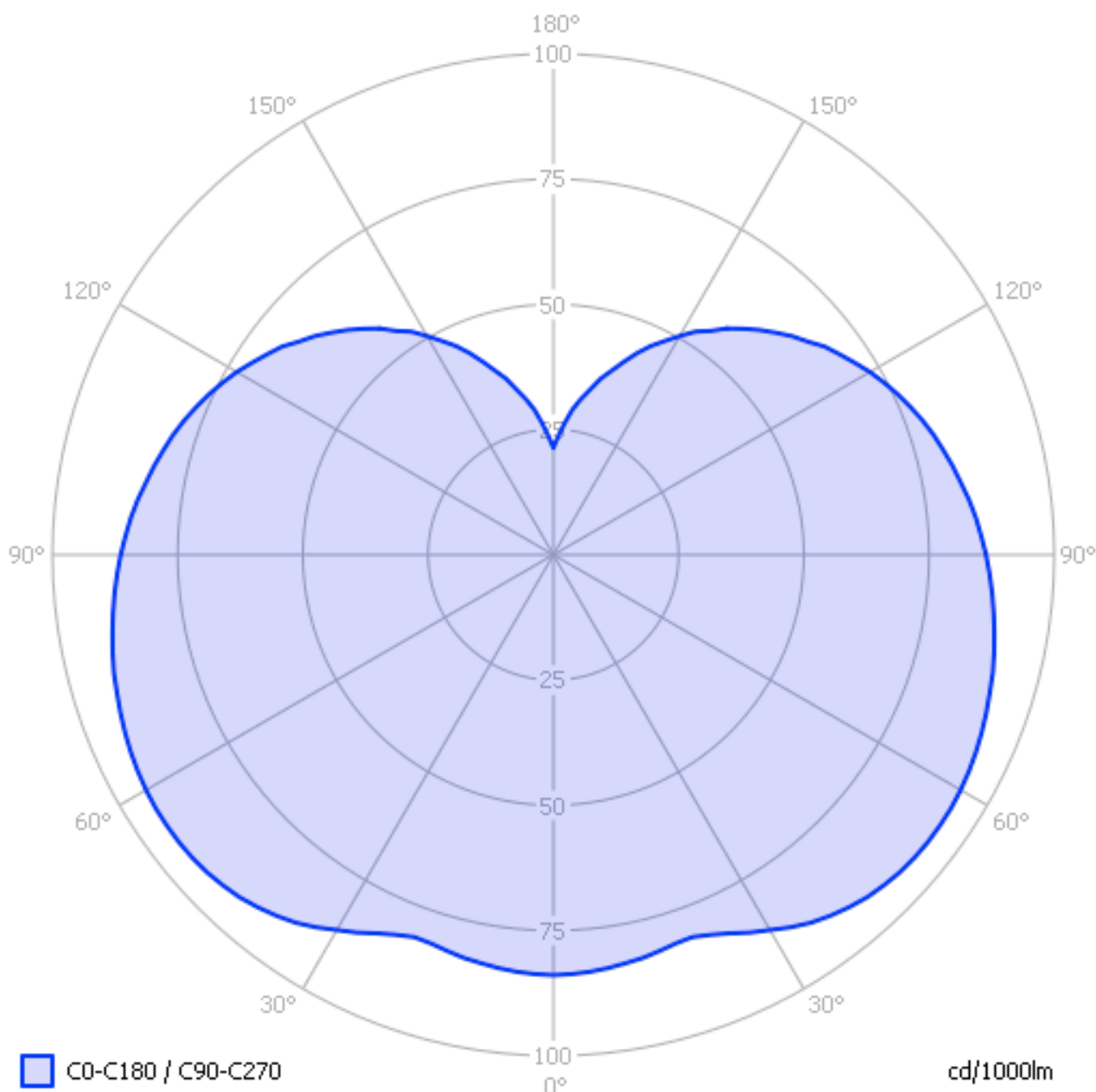# Lamp measurement report – d mmm yyyy

Summary measurement data

parameter	meas. result	remark
Color temperature	2858 K	Warm white
Luminous intensity I_v	13 Cd	
Beam angle	318 deg	
Power P	3.9 W	
Power Factor	0.54	For every 1 kWh net power consumed, there has been 1.5 kVAhr for reactive power.
Luminous flux	159 lm	
Luminous efficacy	41 lm/W	This is the luminaire efficacy (including reflection, absorption, power supply, temperature losses).
CRI_Ra	76	Color Rendering Index.
Coordinates chromaticity diagram	x=0.4427 and y=0.3985	
Fitting	E27	
PAR-value	0.1 $\mu Mol/s/m^2$	The number of photons seen by an average plant when it is lit by the light of this light bulb. Value valid at 1 m distance from light bulb. Valid for roughly the region within the beam angle.
S/P ratio	1.1	This factor indicates the amount of times more efficient the light of this light bulb is perceived under scotopic circumstances (low environmental light level).
D X H external dimensions	62 x 115 mm	External dimensions of the light bulb.
D x H luminous area	62 x 60 mm	Dimensions of the luminous area (used in Eulumdat file). This is equal to the size of the glass of this light bulb.
General remarks		The ambient temperature during the whole set of measurements was 25.5 deg C. The case temperature was not noticeable higher than ambient. Warm up effect: during the warm up time the illuminance and the consumed power decrease with 7 % and 4 % respectively. Voltage dependency: the power consumption nor light output depend on the voltage applied.

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Eulumdat light diagram

An interesting graph is the light diagram, indicating the intensity in the C0-C180 and the C90-C270 plane. This light diagram below comes from the program Qlumedit, that extracts these diagrams from an Eulumdat file.

☐ C0-C180 / C90-C270   cd/1000lm

The light diagram giving the radiation pattern.

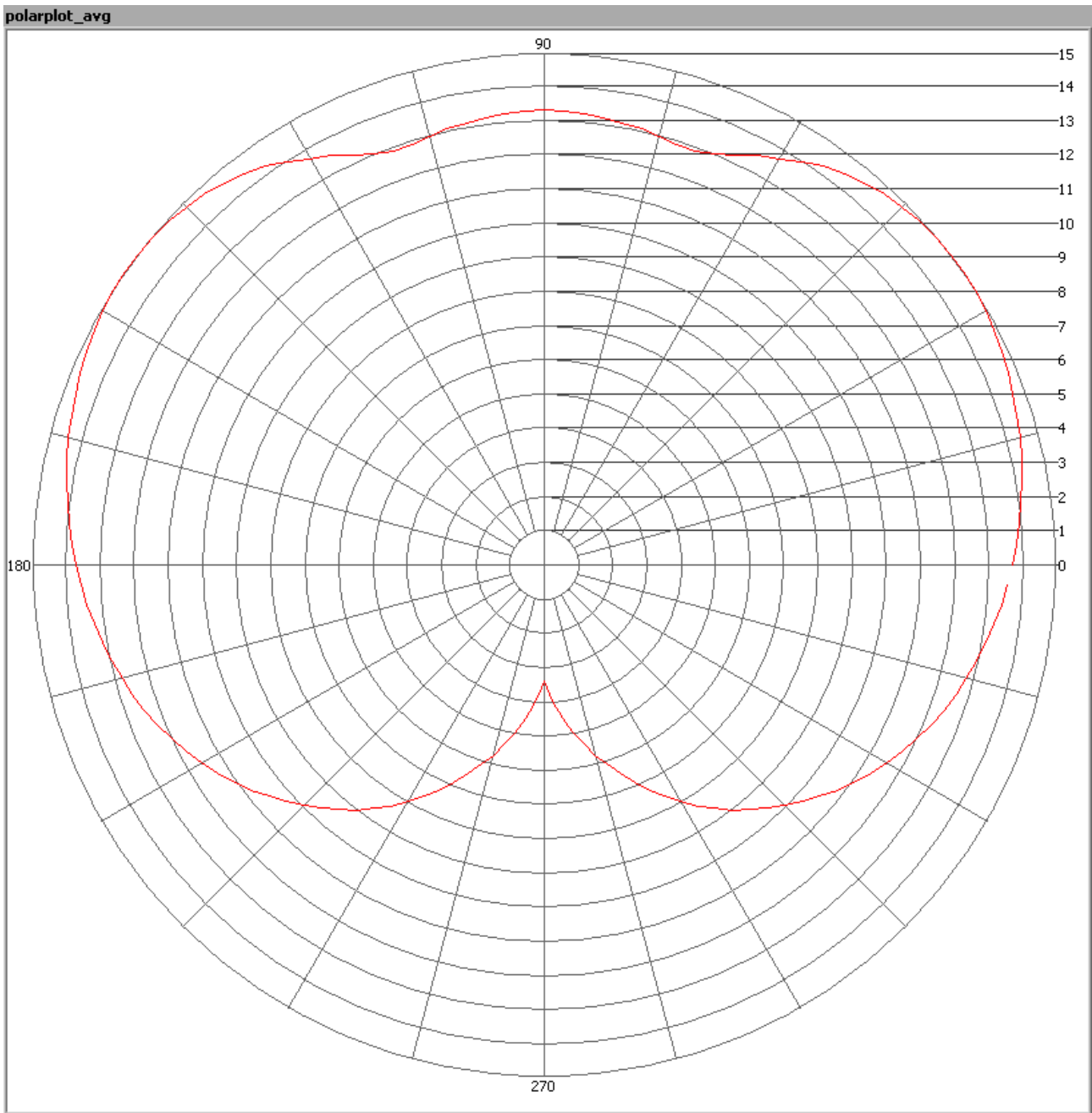It indicates the luminous intensity around the light panel. This light panel has the same

light diagram for the C0-C180 as for the C90-C270 plane since there is symmetry over the z-axis (height of the light bulb).
The unit is Cd/1000lm, meaning the intensity in Cd assuming there would be 1000 lumen in the measured light bulb. This enables comparing different types of light bulbs.

Illuminance Ev at 1 m distance, or luminous intensity Iv

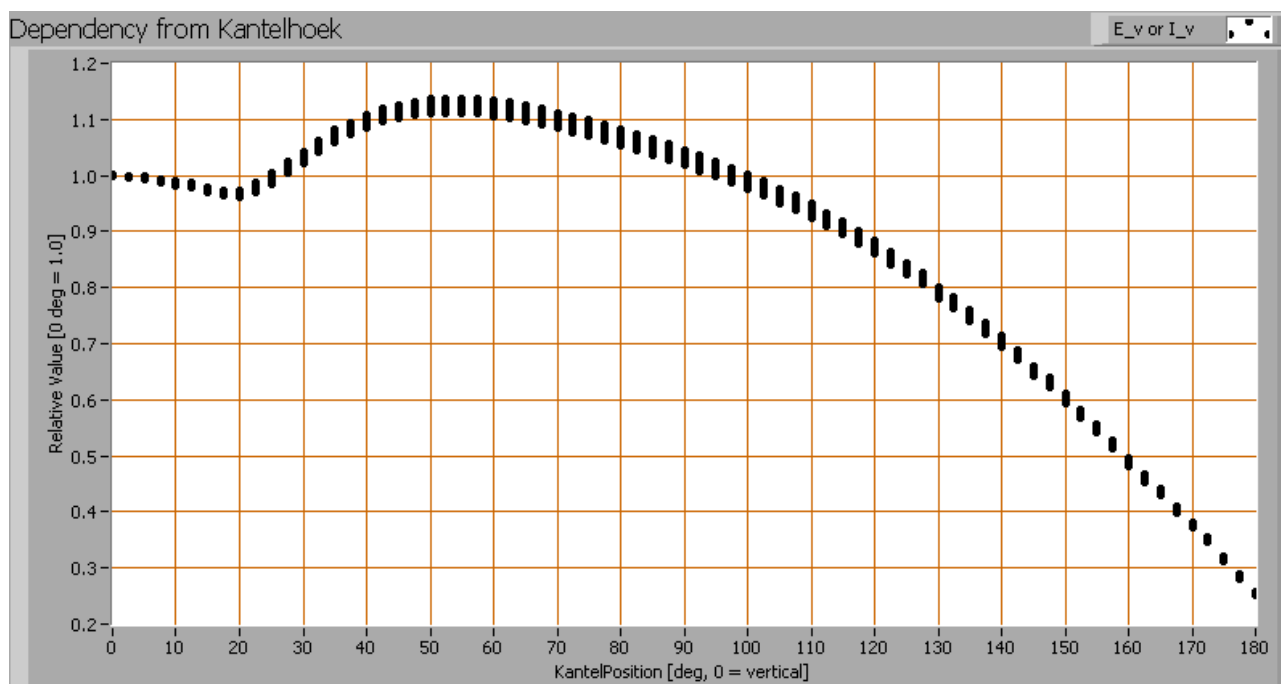Herewith the plot of the *averaged* luminous intensity Iv as a function of the inclination angle with the light bulb.

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The radiation pattern of the light bulb.

This radiation pattern is the average of the light output of the light diagram given earlier. Also, in this graph the luminous intensity is given in Cd.
These averaged values are used (later) to compute the lumen output.

Intensity data of every measured turn angle at each inclination angle.

This plot shows per inclination angle the intensity measurement results for each turn angle at that inclination angle. There normally are differences in illuminance values for different turn angles. However for further calculations the averaged values will be used. When using the average values per inclination angle, the beam angle can be computed, being 318 degrees.

Luminous flux

With the averaged illuminance data at 1 m distance, taken from the graph showing the averaged radiation pattern, it is possible to compute the luminous flux.
The result of this computation for this light spot is a luminous flux of 159 lm.

Luminous efficacy

The luminous flux being 159 lm, and the power of the light bulb being 3.9 W, yields a luminous efficacy of 41 lm/W.
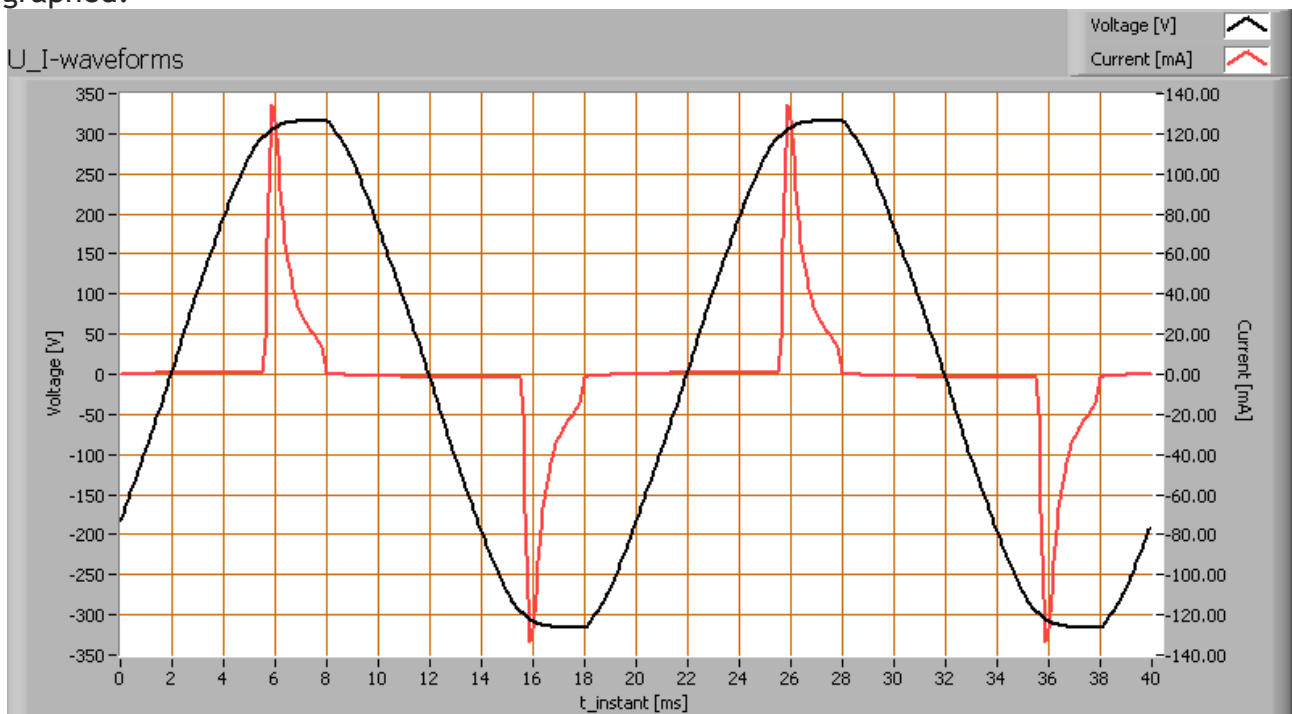A power factor of 0.54 means that for every 1 kWh net power consumed, a reactive

component of 1.5 kVAr was needed.

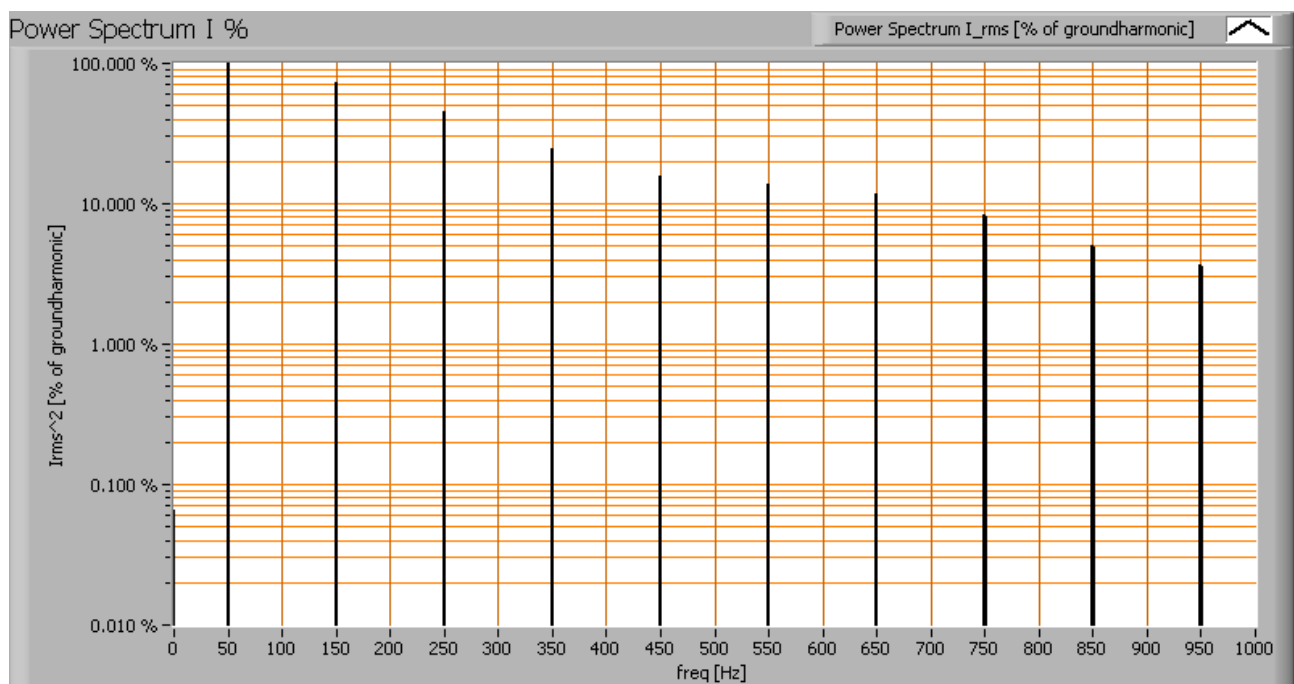| Light bulb voltage	230 VAC
Light bulb current	31 mA
Power P	3.9 W
Apparent power S	7.2 VA
Power factor	0.54

Of this light bulb the voltage across ad the resulting current through it are measured and graphed.

Voltage across and current through the lightbulb

The current is out of phase with the voltage, and it shows peaks as well.

Also the power spectrum of the current is determined.

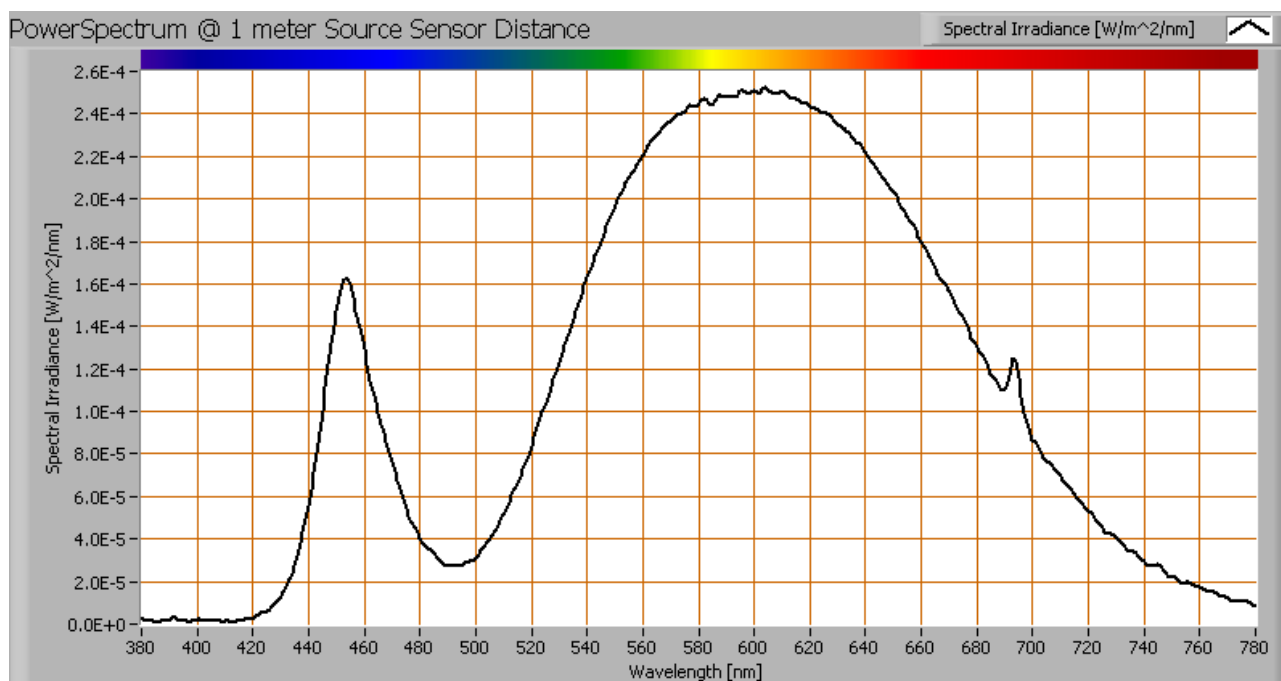*Current power spectrum in % of the first harmonic (50 Hz).*

The peaks in the current result in a lot of higher harmonics.

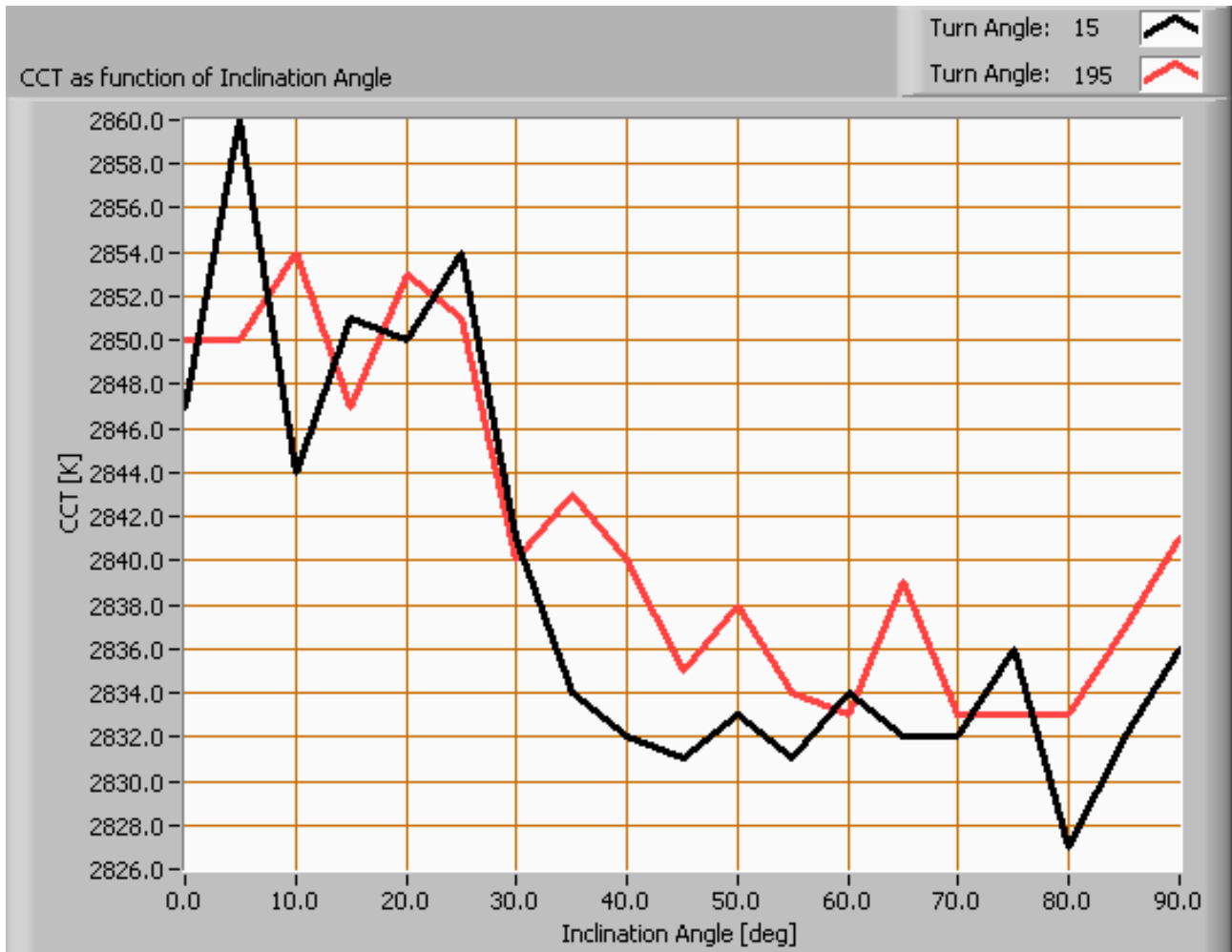## Color temperature and Spectral power distribution

The spectral power distribution of this light bulb, energies on y-axis valid at 1 m distance.

The measured color temperature is about 2850 K which is warm white.
This color temperature is measured straight underneath the light bulb. Below a graph showing the color temperature for different inclination angles.

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Color temperature as a function of inclination angle.

Measured is in the angles 15 and 195 degrees, and the measurement of CCT has been stopped when less than 5 lux were measured or when the inclination angle was 90 degrees, which was the case for this light bulb.
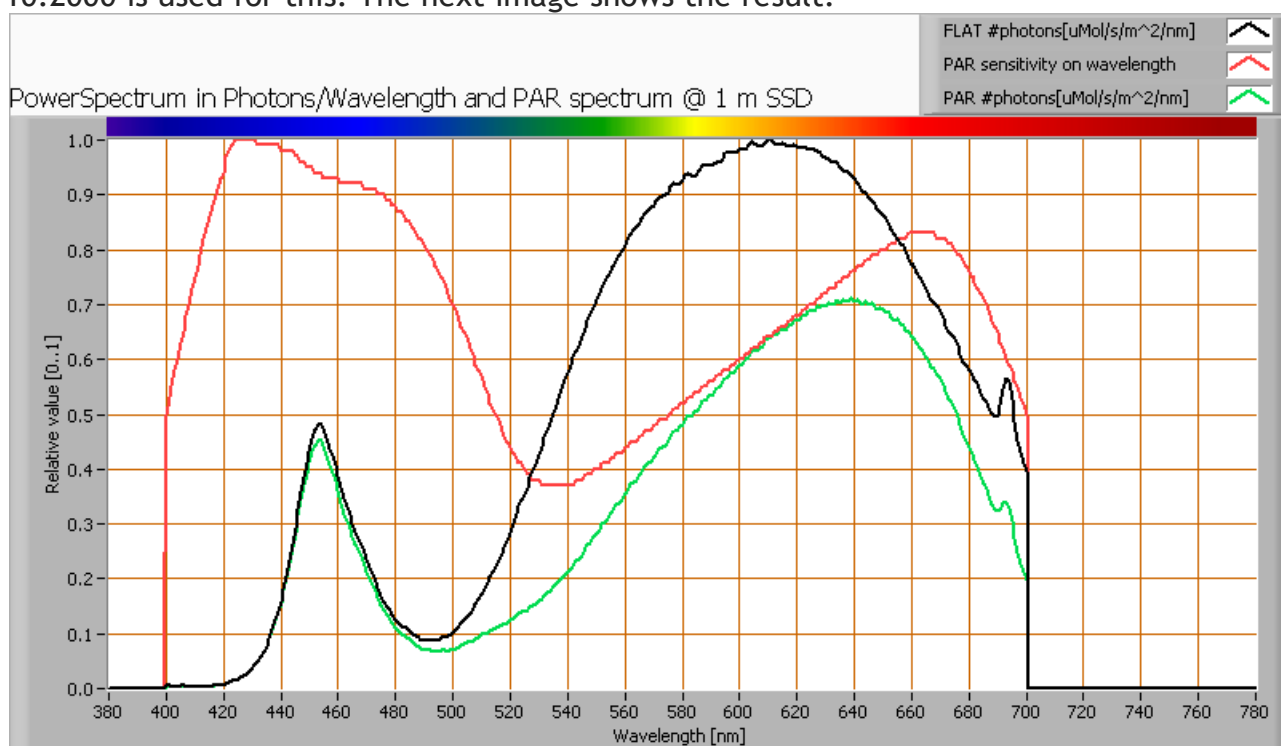
The maximum beam angle is 318 degrees, meaning at an inclination angle of 159 degrees there is 50 % left of the initial illuminance value at 0 degrees. Most of the light energy is within this area. We only have the data until 90 deg inclination angle. In this area the color temperature stays within 1 % of its value at 0 degrees inclination angle.

PAR value and PAR spectrum

To make a statement how well the light of this light bulb is for growing plants, the PAR-area needs to be determined. PAR stands for Photosynthetic Active Radiation which is that radiation that participates actively to photosynthesis and is expressed in µMol/s/m². Photosynthesis is the essence for growth and flowering of plants, where the blue part of the light spectrum is responsible for growth and the red part is responsible for flowering and budding (for gemmation). For photosynthesis it is more important to count the number of photons rather than the power in the light.

The power spectrum (power per wave length) of the light of the light bulb is converted into the number of photons (number of photons per wave length) and then these number of photons is weighted against the relative sensitivity of an average plant (which varies in value dependent on the wave length). The relative sensitivity curve in DIN-norm 5031-10:2000 is used for this. The next image shows the result.

The photon spectrum, then the sensitivity curve and as result the final PAR spectrum of the light of this light bulb

The black curve gives the power spectrum of the light of this light bulb, in number of photons per wave length.

In red the relative sensitivity curve of an average plant (according to DIN norm 5031-10:2000).

Multiplying these two results in a curve showing the number of photos per wave length of the light of this light bulb, the PAR spectrum.

Summing all the photons, gives a PAR number that for this light results in 0.1 $\mu Mol/s/m^2$. This value is valid at 1 m distance from the light bulb and for the area within the beam angle.

Dividing the PAR number by the total number of photons of the light of this light bulb gives a sort of PAR efficiency, which is 64 % (valid for the PAR wave length range of 400 - 700 nm). So maximally 64 % of the total of photons in the light is effectively used by the average plant (since the plant might not take 100 % of the photons at the frequency where its relative sensitivity is 100 %).
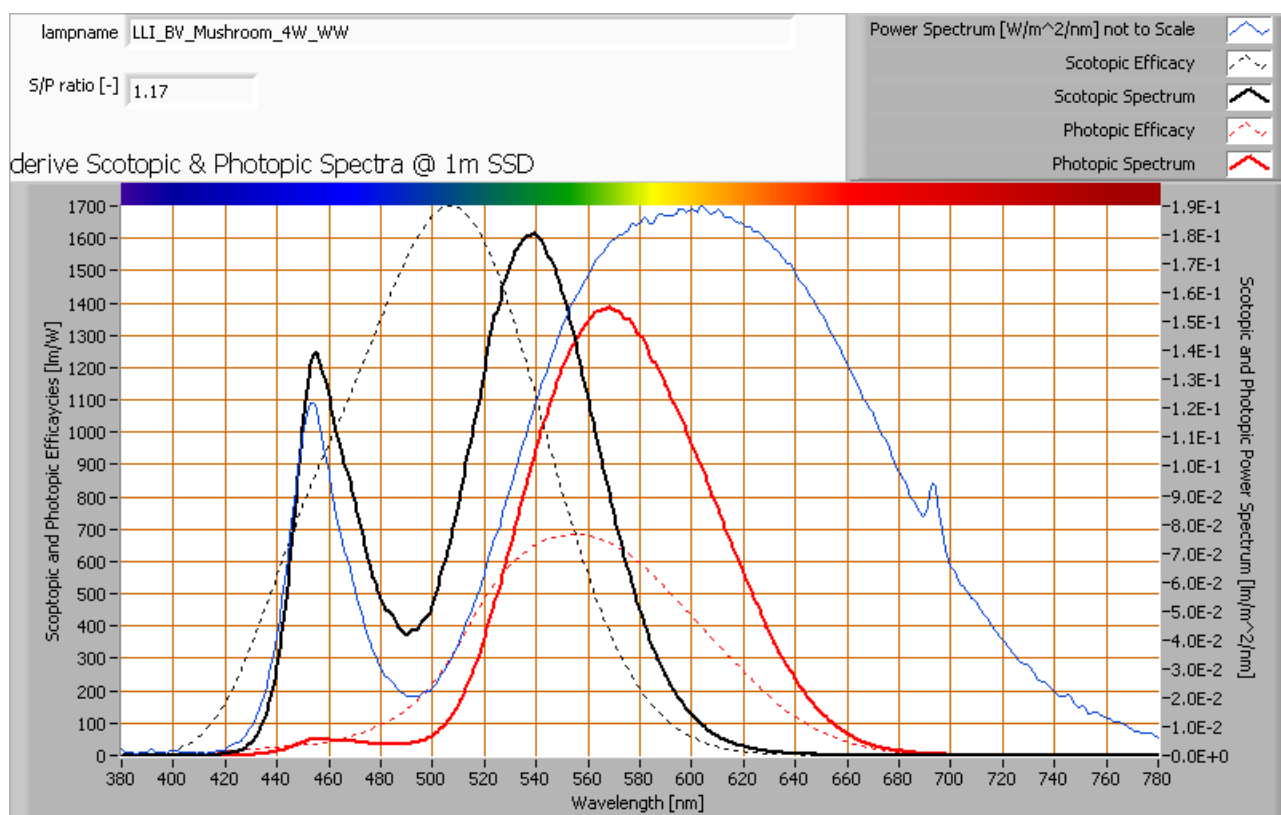
Note: when mentioning this percentage of efficiency, it is important to verify if all wavelengths are present in a sufficient manner. Not that only blue light is available, when the plant is going to be used for flowering where specifically red light is needed.

S/P ratio

The human eye uses rods and cones. The rods work at scotopic light levels (twilight, night) and the rods at high(er) light levels (daytime, but also close to twilight). Each type of receptor has its own sensitivity for light. The rods are 2.7 times more sensitive than cones, and most for light at a blueish-greenish color whereas compared to the cones' sensitivity for green light (555 nm). The S/P ratio gives the maximum difference in sensitivity of the rods at their most sensitive wavelength compared to the cones at their's. The more blueish (cold white) the light, the more the S/P ratio can be.

The light of this light bulb has a certain spectrum leading to an S/P ratio of 1.1. The light of this lightbulb at scotopic light levels is perceived this factor higher than it would be a photopic light levels.
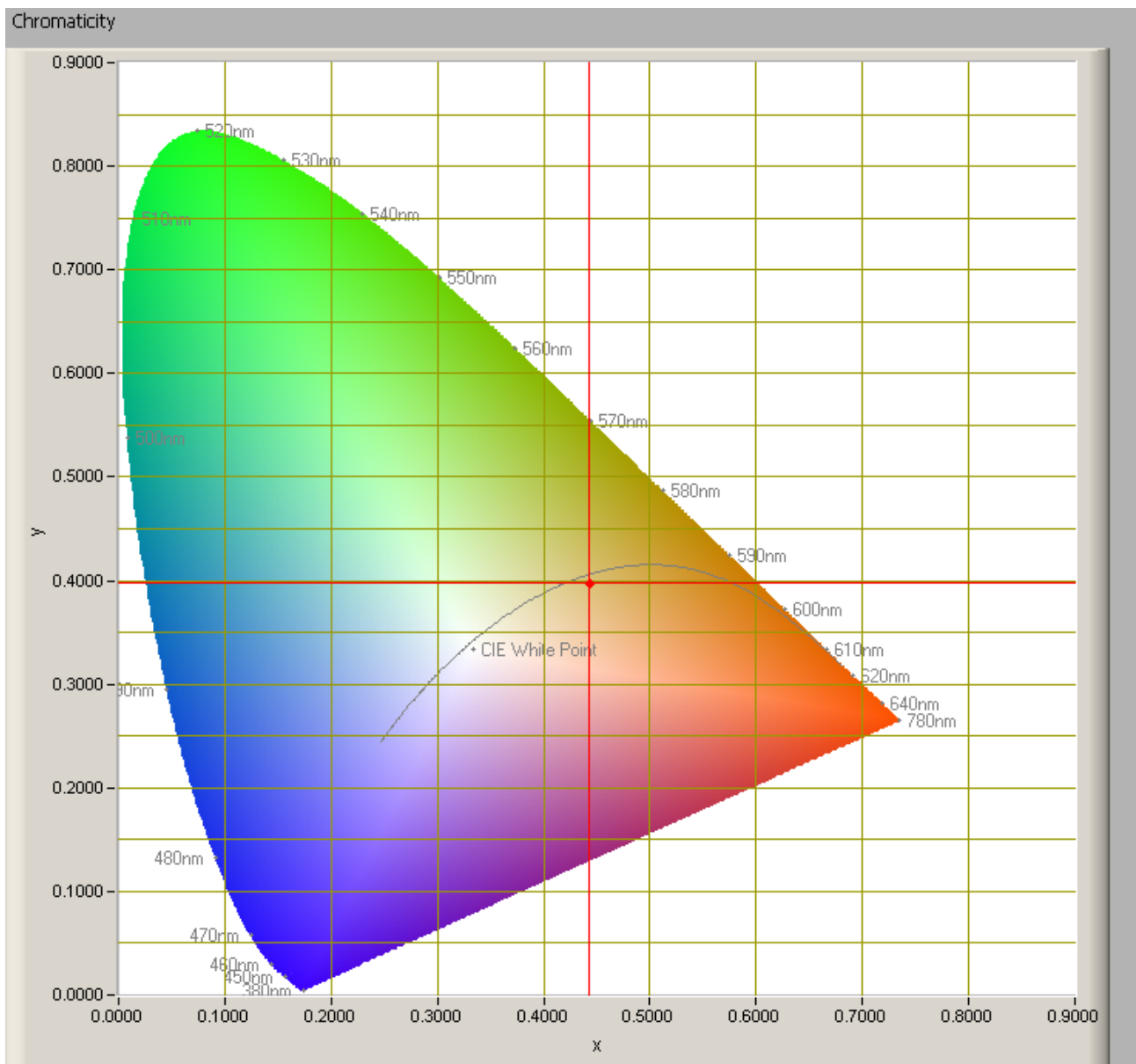
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The power spectrum, sensitivity curves and resulting scotopic and photopic spectra (spectra energy content defined at 1 m distance).

There's little blue with respect to green/yellow (see the blue line), resulting in an S/P ratio which is rather low being 1.1.

Chromaticity diagram

The chromaticity space and the position of the lamp's color coordinates in it.

The light coming from this lamp close to the Planckian Locus (the black path in the graph).

Its coordinates are x=0.4427 and y=0.3985.

Color Rendering Index (CRI) or also Ra

Herewith the image showing the CRI as well as how well different colors are represented (rendered). The higher the number, the better the resemblance with the color when a black body radiator would have been used (the sun, or an incandescent lamp).

Each color has an index Rx, and the first 8 indexes (R1 .. R8) are averaged to compute the Ra which is equivalent to the CRI.

manual	
Reference Illuminant	Planckian radiator ▼ CCT 2858 K
Chromaticity Difference DC=	2.9E-3

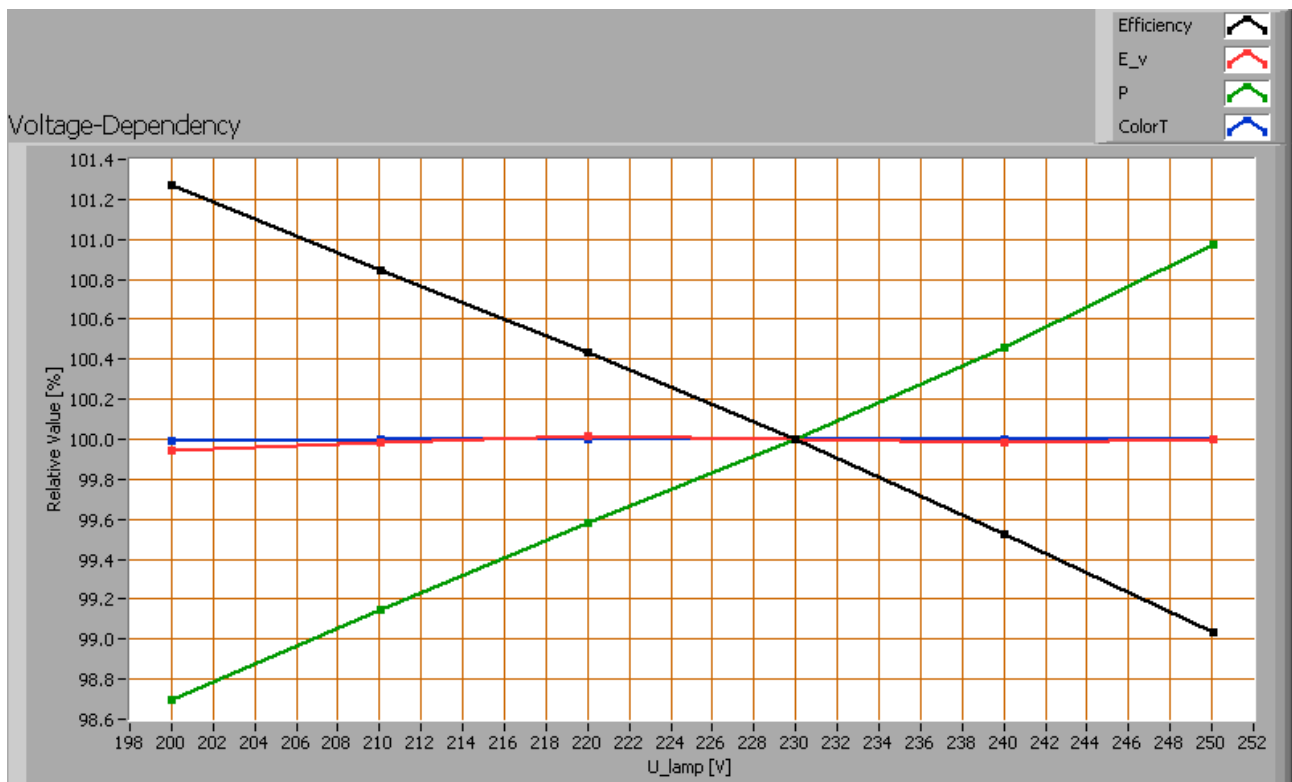|					Ra
R1=	74.1	R8=	62.6		(mean value of R1 - R8)
R2=	84.9	R9=	14.6		
R3=	89.7	R10=	60		75.8
R4=	67.7	R11=	56		
R5=	69.2	R12=	44.1		
R6=	72.8	R13=	75.8		
R7=	85.1	R14=	93.3		

CRI of the light of this lightbulb.

The value of 76 is (a little) lower than 80 which is considered a minimum value for indoor usage.

Note: the chromaticity difference is 0.0029 indicates the distance to the Planckian Locus. Its value is lower than 0.0054, which means that the calculated CRI result is meaningful.

Voltage dependency

The dependency of a number of lamp parameters on the lamp voltage is determined. For this, the lamp voltage has been varied and its effect on the following light bulb parameters measured: illuminance E_v [lx], the lamppower P [W], the (Correlated) Color Temperature [K] and the luminous efficacy [lm/W].

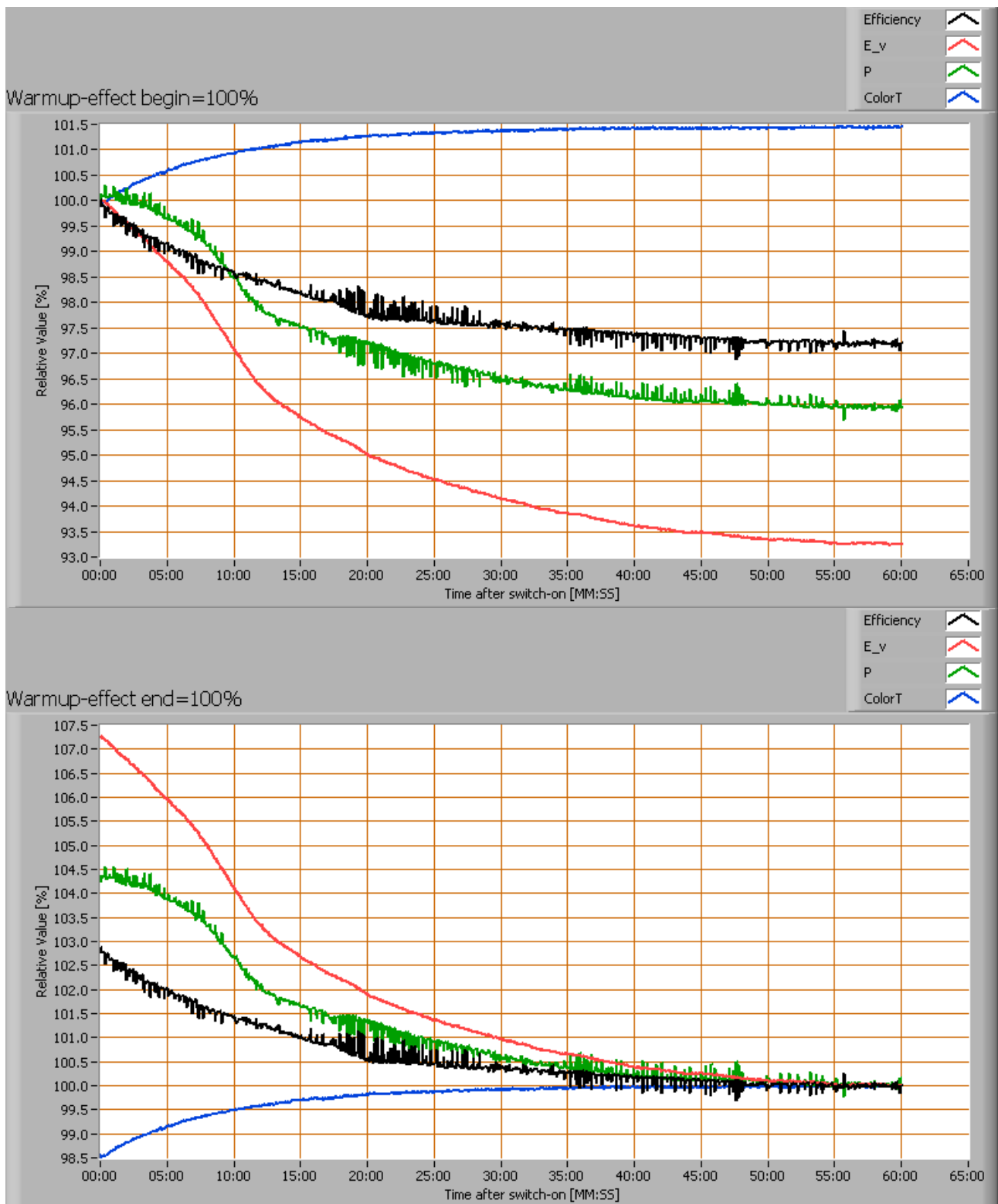*Lamp voltage dependencies of certain light bulb parameters, where the value at 230 V is taken as 100 %.*

Variation of parameters is small and insignificant when the voltage varies between 200-250 V.

When the voltage at 250 V varies with + and - 5 V, then the illuminance varies within 0.1 %, so when abrupt voltage changes occur this effect is not visible in the illuminance output.

Warm up effects

After switch on of a cold lamp, the effect of heating up of the lamp is measured on illuminance E_v [lx], color temperature CT or correlated color temperature CCT [K], the lamppower P [W] and the luminous efficacy [lm/W].

Effect of warming up on different light bulb parameters. At top the 100 % level is put at begin, and at bottom at the end.

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During a warm up time of about 35 minutes, the illumination drops with 7 % and the consumed power with 4 %.

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